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Rutherford Appleton Laboratory

"Near Detector Physics" Plenary Session:

- ***Event Slicing*** *(in AltReco package)*
- ***Neutrino Interaction Model Validation***

also for Hugh Gallagher

Costas Andreopoulos <*C.V.Andreopoulos@rl.ac.uk*>

Event Slicing

Package: **AltReco**

- *neural-net based reconstruction*
- *event slicing*

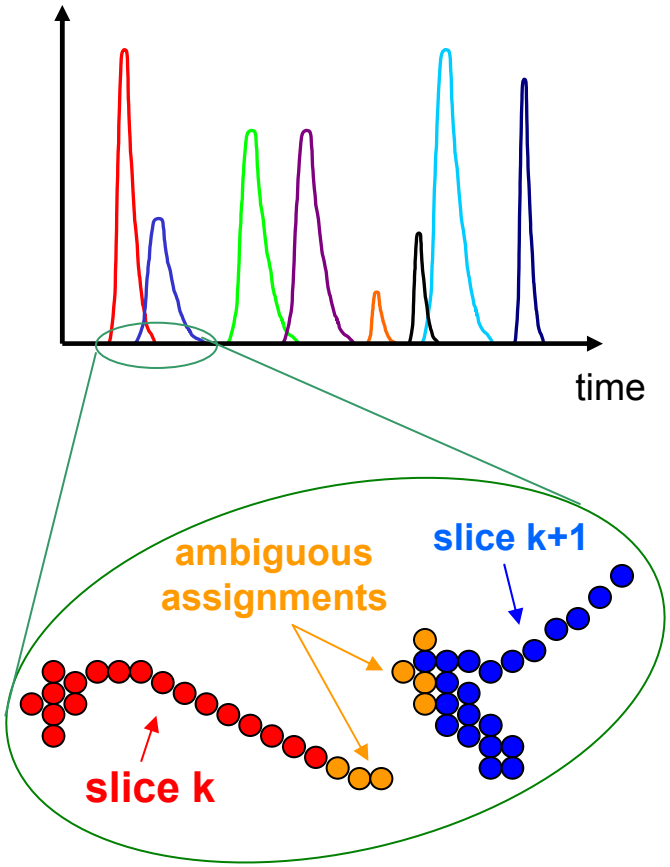
I will focus on this

- *the principle*
- *examples*
- *current status*
- *future work*

Near Detector Event Slicing – 1/3

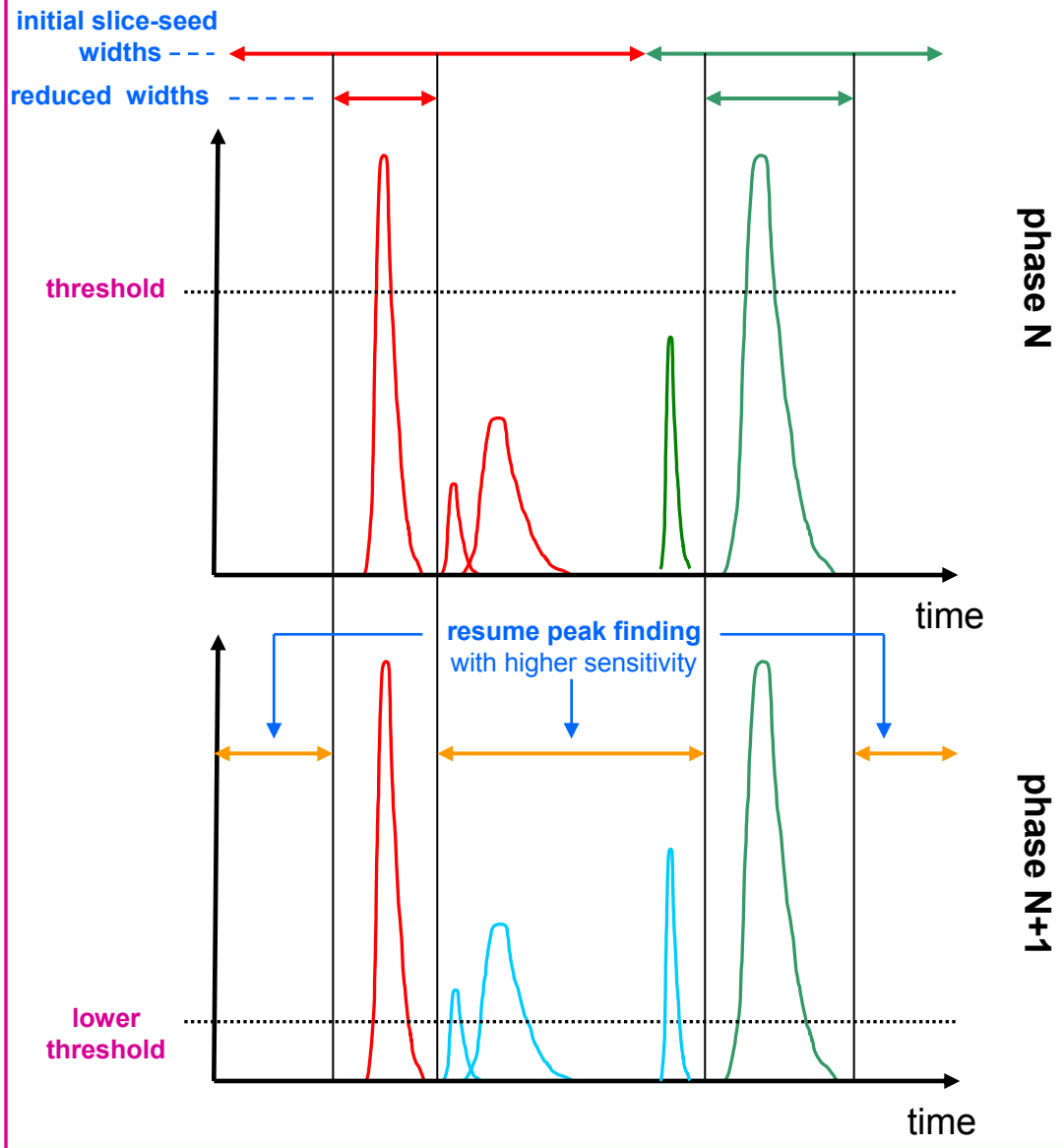
The general approach

Obtain slice-seeds by finding *peaks in the time profile*



Resolve ambiguities (overlaps in time) by *looking at topological information*

The peak finder works 'recursively'



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Near Detector Event Slicing – 2/3

…and then, the slice seeds are refined

- ***Filtering***

Slices seeds that are too small or to scattered are dissolved and the 'orphan strips' are assigned to the best available slice…

- ***Merging***

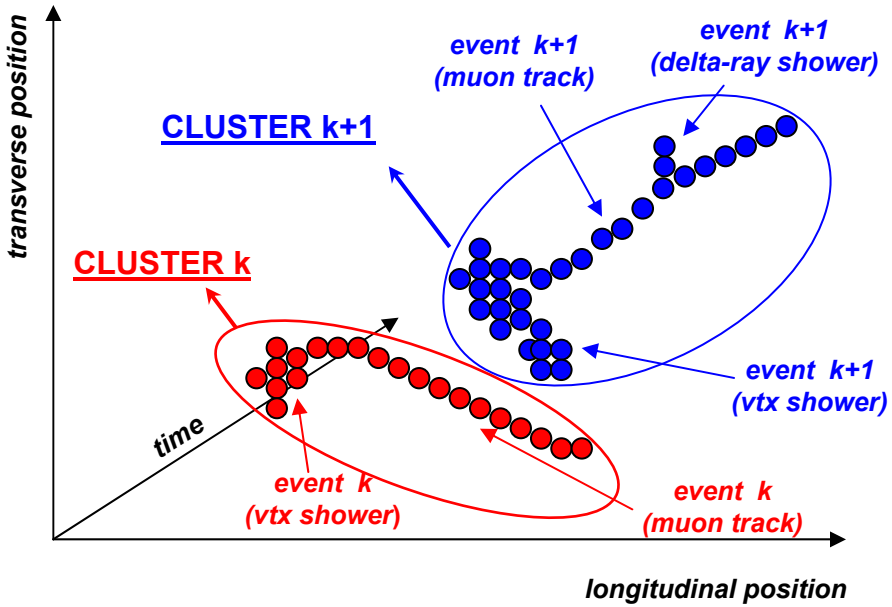
Where it seems that an event is 'broken' and its hits distributed in > 1 slices, the slices are merged

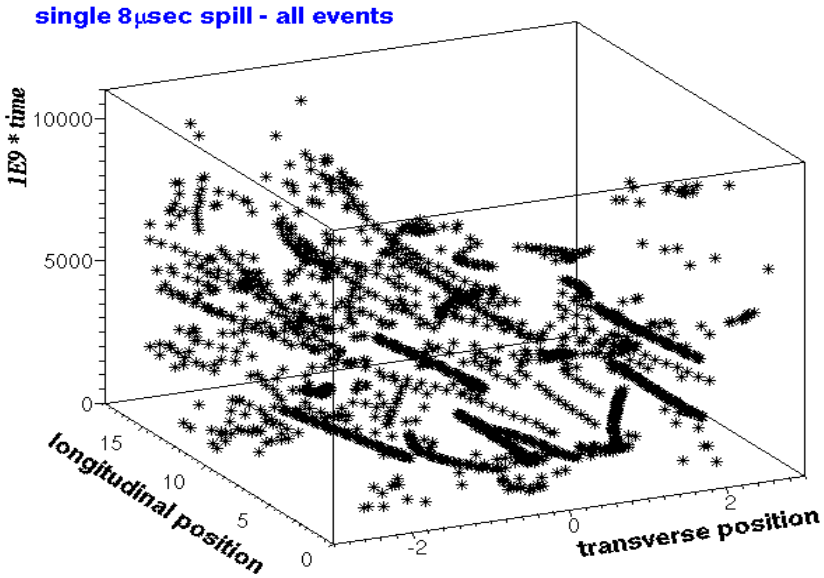
- ***k-Means (non-hierarchical) 3-D clustering***

Try to fix strip mis-assignments between slices using 3-D clustering. The cost function (that was based on a 'Euclidian' metric) has now be replaced by a 'decision tree'… Preserves the number of slices unless one of them is stripped out…

- ***Minimal Spanning Tree (hierarchical) 3-D clustering***

Check for substructure within each slice (not there yet)





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Near Detector Event Slicing – 3/3

At the end muon spectrometer hits are assigned to each slice…

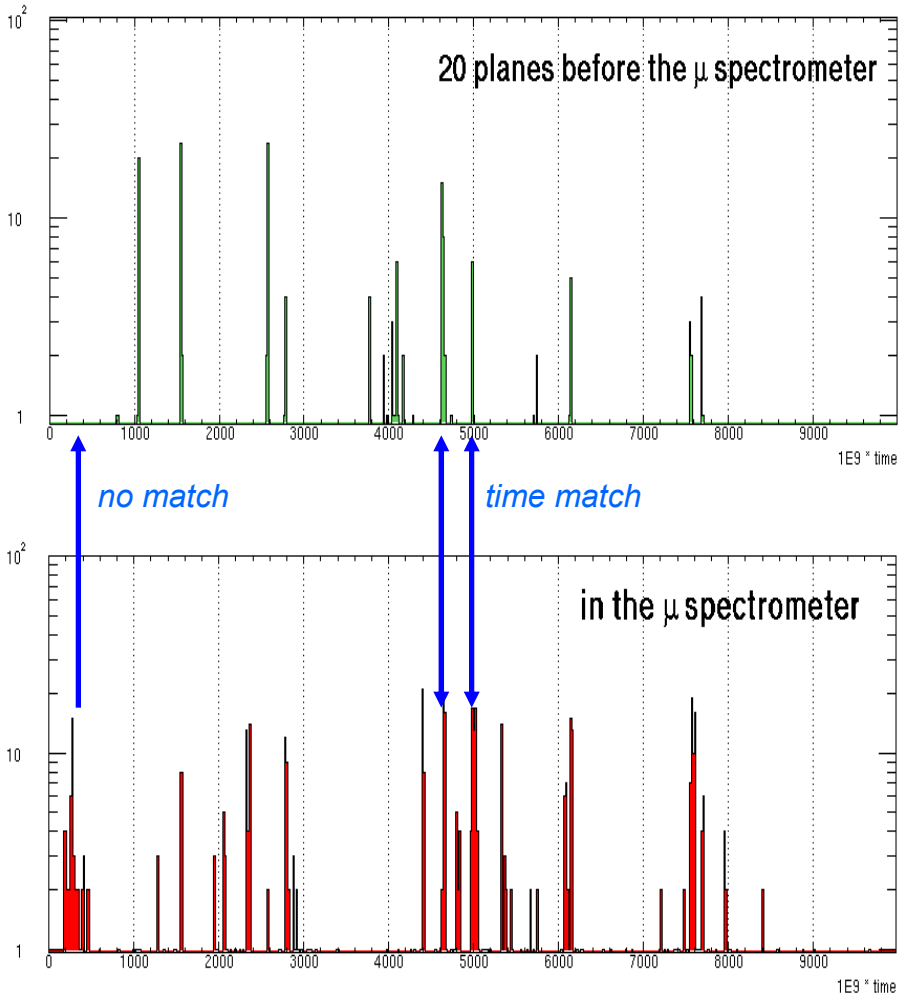
- ***Form temp. slices in the muon spectrometer***
  Using the procedure outlined before

- ***Reduce combinatorials***
  Take only upstream slices with activity just before the muon spectrometer

- ***Make associations***
  Try to match upstream slices with muon spectrometer slices

  → ***Match found ?***
  Merge the hit strip lists

  → ***Match not found ?***
  Promote the temporary muon spectrometer slice into a normal slice so as to host the muon spectrometer hits and pass them on…



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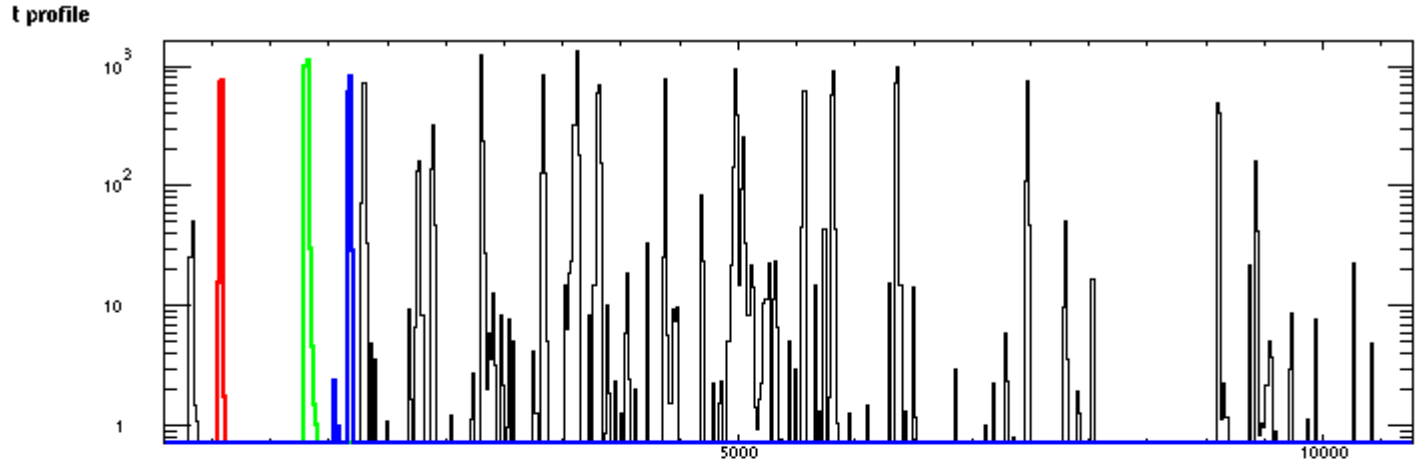
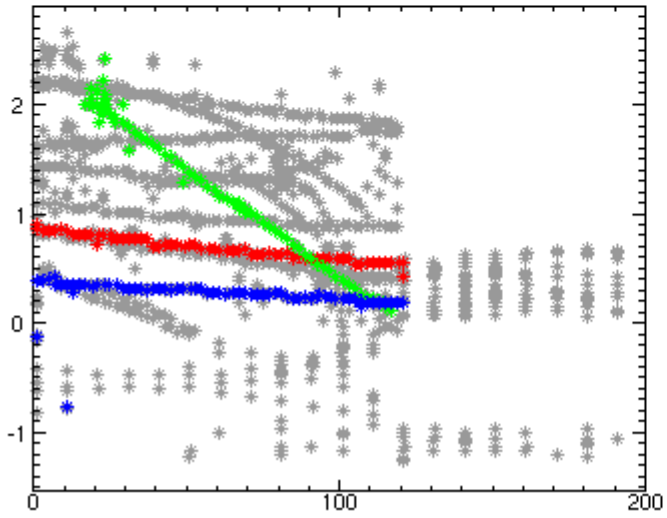
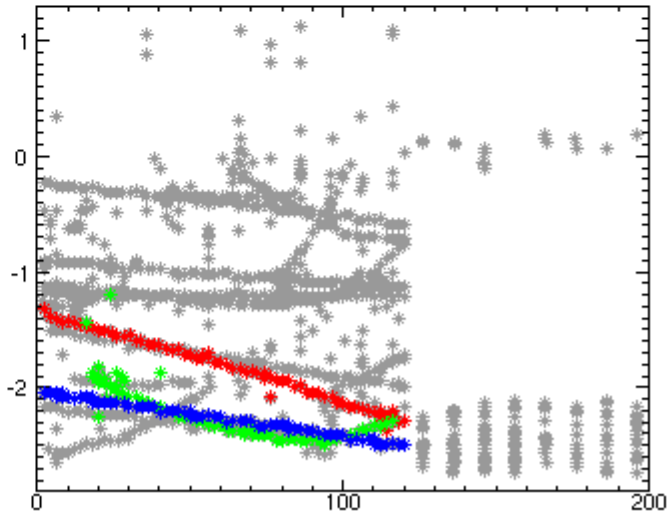
Event Slicing – An example 1/3



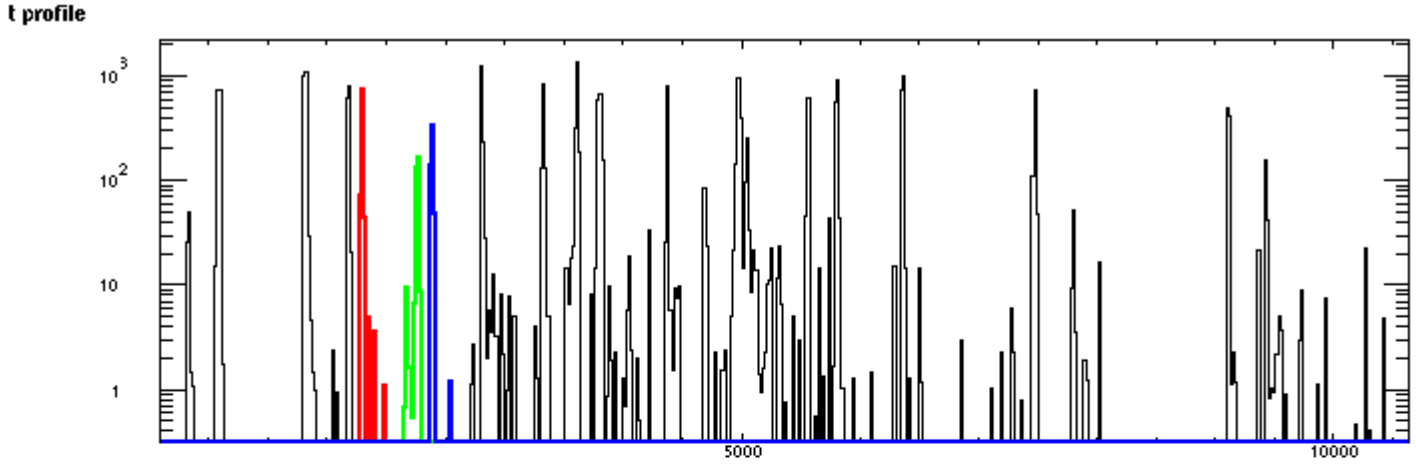
UZ-view

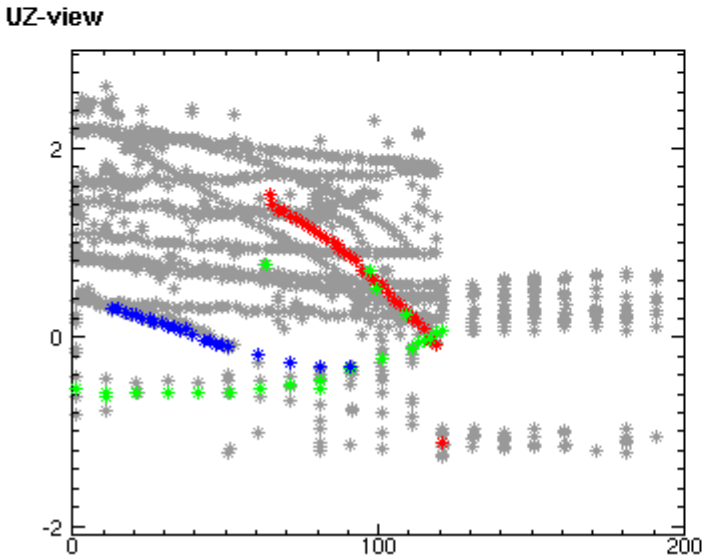


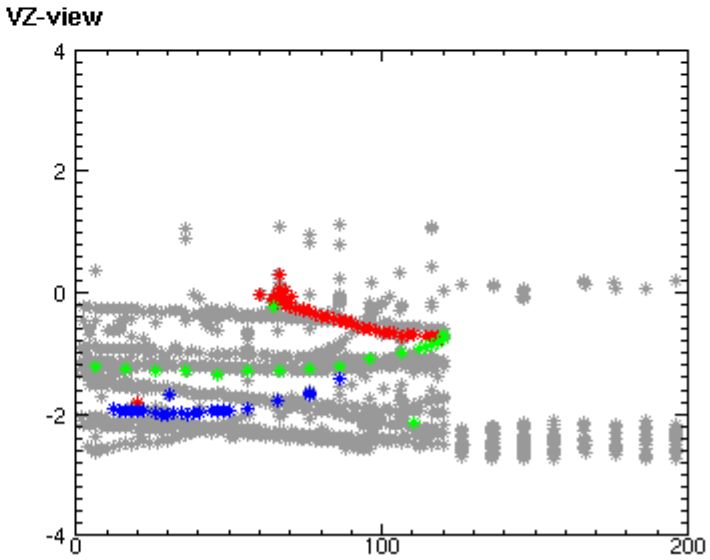
VZ-view



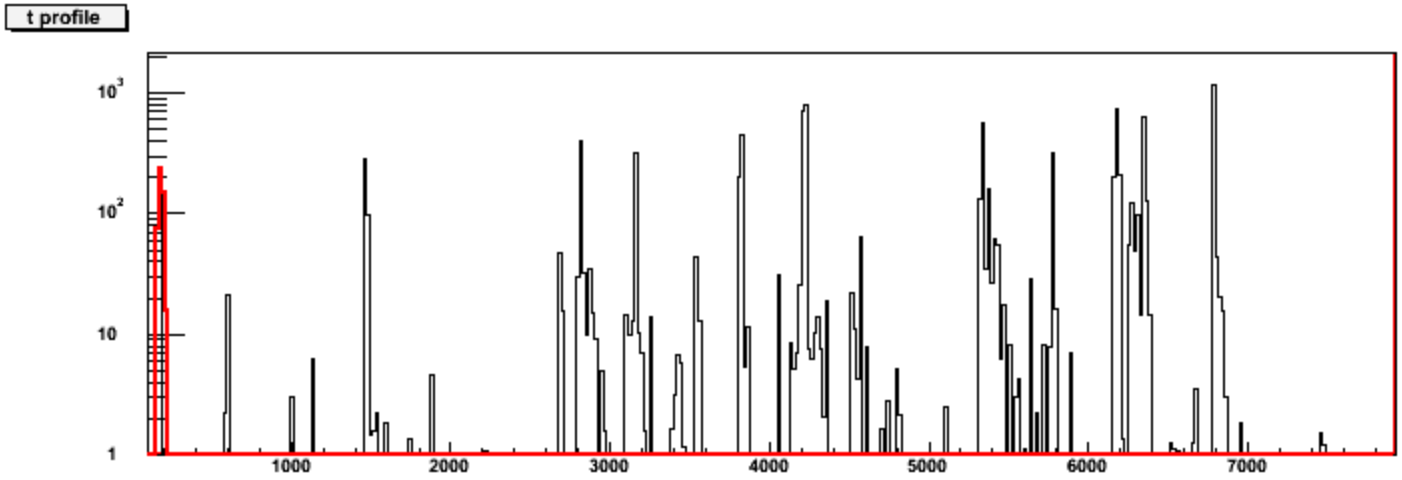
Event Slicing – An example 2/3



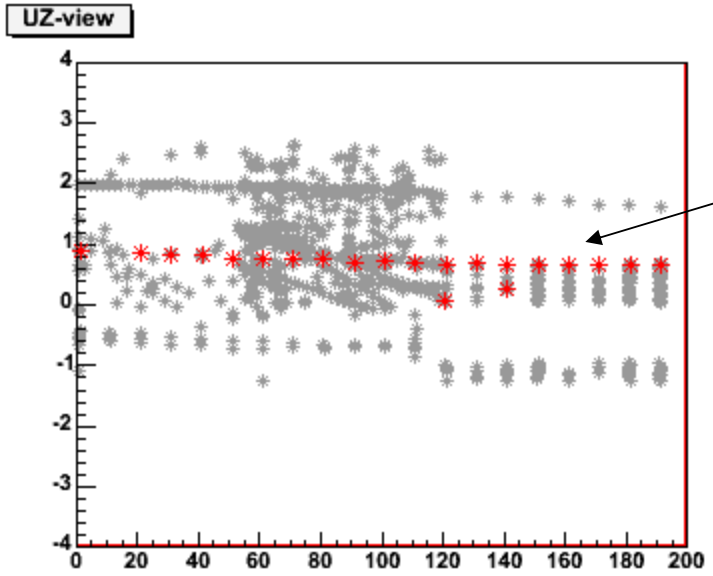


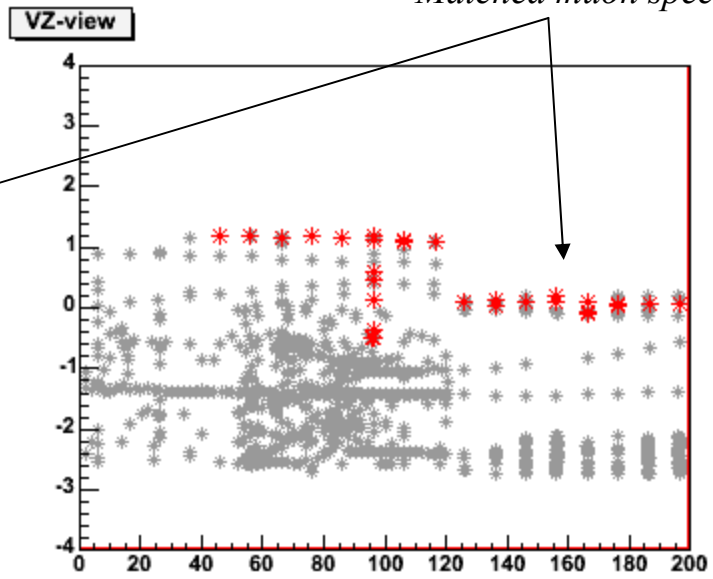


Event Slicing – An example 3/3



Matched muon spectrometer hits





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Event Slicing – Current Status

Generally: Event slicing is a quite complex task and AltReco's slicer is ~4 months old. In general, it works… but it is in transitional state and has some problems.

GOOD:

- *Speed does not seem to be an issue*
  (although new features were added in a gross way and there is much room for improvement)
- *Does not seem to have leaks (?)*
- *Does not seem to have gross bugs (?)*
- *Is sufficiently protected (?)*
  (if something goes wrong, the slice quality might be degraded but it will not die)
- *But, there is room for improvements and it is one of my highest priorities in my work schedule…*

BAD:

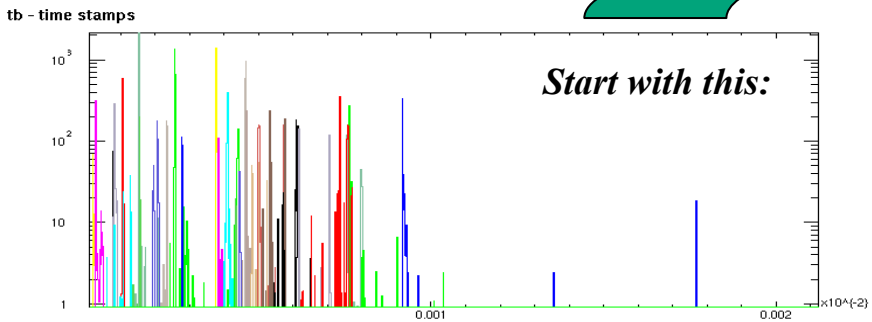
- *Jim has just reported to me* ***some problems in matching muon spectrometer hits with upstream slices****…*
  Will have to investigate with him ASAP…
- ***Directly reflecting my fear when I first start working with this*** *(that in some cases it will be impossible to separate events)* ***the slicer is 'very sensitive'****…*
  I think that sometimes, fearing not to merge two events in a slice, it splits a single event in two slices.
  (the new MC will help me to work on this – see next slice)

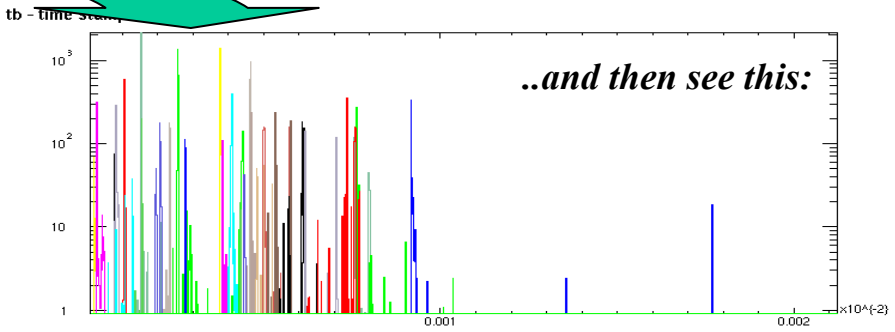
UGLY:

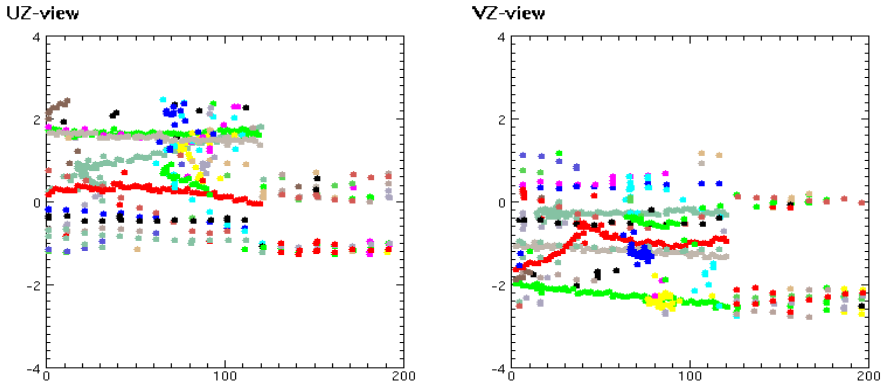
- *Checking the quality of reconstructed slices or, what was the effect of a change is a nightmare…*

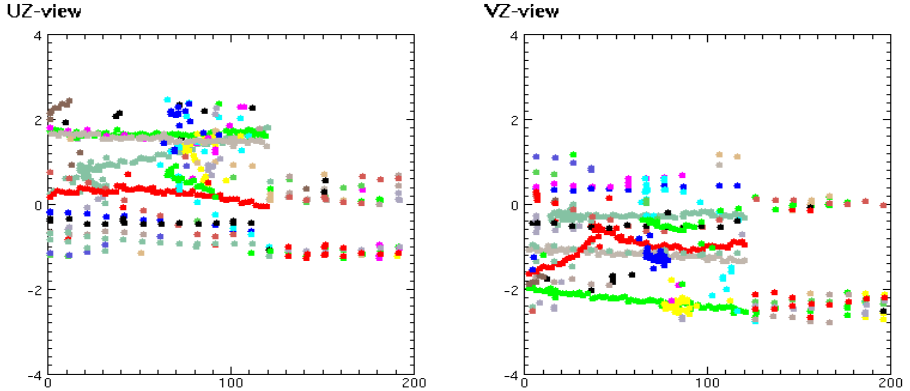
Work to be done… Higher priorities

do a change







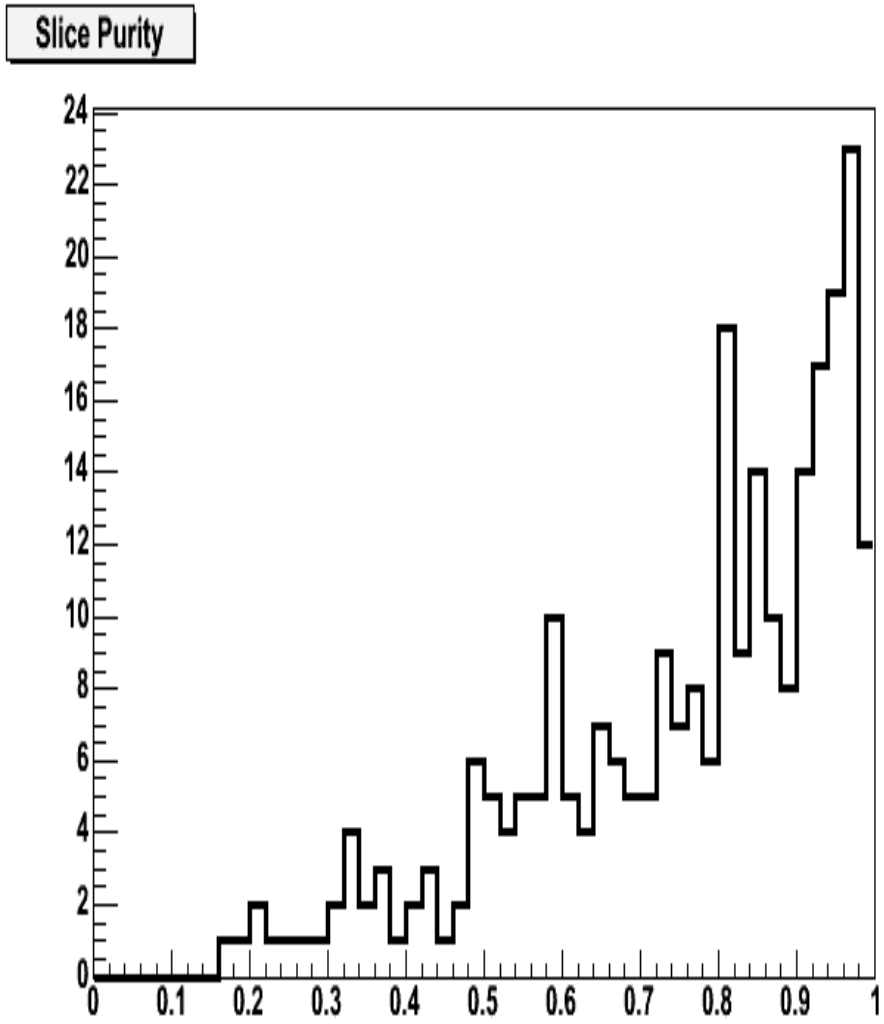


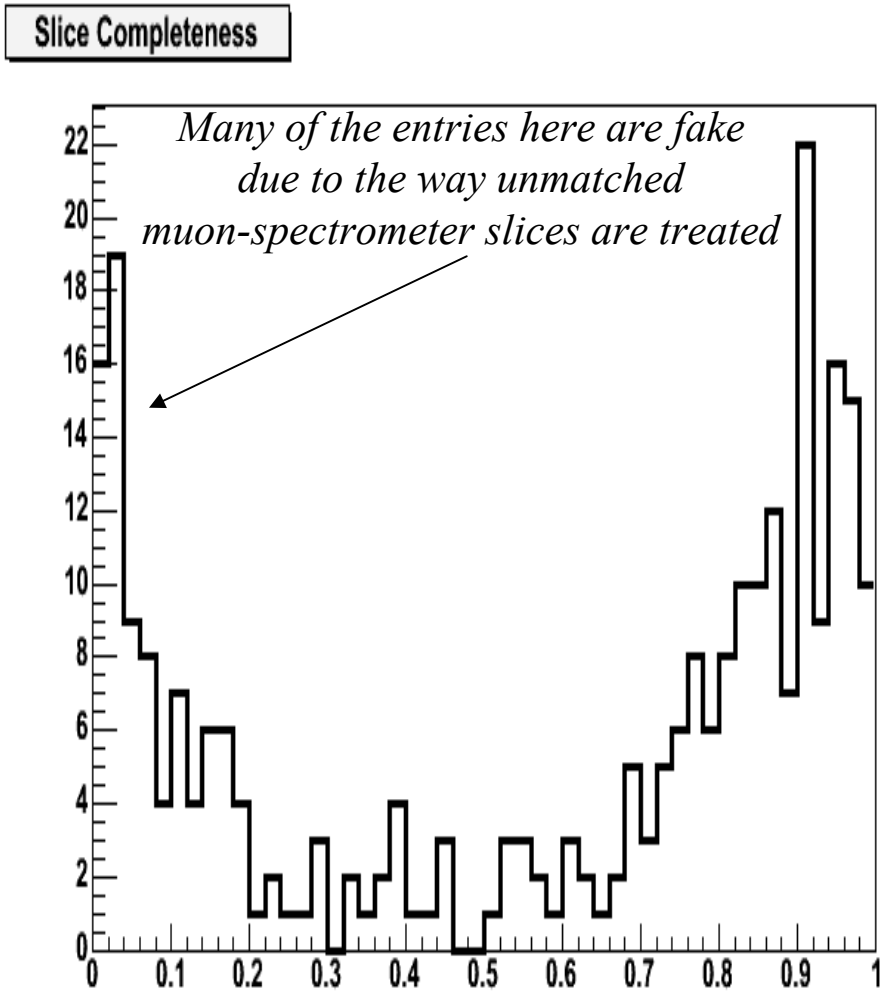
So… what was the effect?

*The slicer was built/debugged using the old MC. The **new MC** was very recently made available. I am becoming more familiar with it and I am trying to **develop some tools to help me use its back-tracking capabilities for debugging purposes***

Out of this effort, I expect significant improvement in the quality of reconstructed slices

Slice purity & completeness





AltReco/Slicer : Conclusions / Requests / Discussion Topics

I think that AltReco/Slicer is in good shape given the complexity & its development stage.

Probably, not suitable for use before I have finished the current development cycle,
created my quality check tools and tested it with the new MC.

The mock data challenge is… a 'challenge'. But if it is not ready for it, let it be so.
The real challenge is the NearDet data…
I do not feel it is appropriate to start patching it up with quick & dirty fixes
so as to meet with mock data challenge deadlines…

Request:
*Current MC data files have *lots* of neutrino interactions per spill.*
They correspond to realistic event rates… but do not help in debugging.
Could we have a couple of files with lower rate? Can I make them by myself?

Discussion Topic:
How do I know that the slicer is "ready", or in better shape than the "standard" one.
What is the 'requirement'?

And now…switching to another topic

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Neutrino Interaction Model Validation

GOAL:

*We want to built a **comprehensive** and **validated** (to the degree it is possible) database of **existing neutrino and electron scattering data** and a set of software tools for interfacing the database with neutrino generators*

OUTLINE:

- ***Motivation:*** *Applications & a MINOS-specific use case*
- *Collecting & validating the data*
- *The **DURHAM Neutrino Cross Section Data Web page***
- *NuValidator: **An Overview***
- ***Current collection of digitized cross section data***
- ***XML:** An Example*
- *Technicalities: **XML parsing, dBase uploading, parsed-data "buffer"***
- ***RDBMS Tables***
- ***Current Status & Future work***

Applications & a MINOS-specific use case

One can imagine a host of different applications for this kind of database:

- *validating event generators*
- *evaluating different models for some process*
- *as a development tool for generators (regression testing)*
- *characterizing systematic uncertainties*
- *tuning model parameters*
- *quantifying systematic uncertainties*

qualitative

quantitative

MINOS-specific use case: *After 1 year, ND data and MC* ***don't*** *agree.*

The interaction model is ***re-tuned*** *to the ND data –*
while maintaining consistency with existing measurements*.*

Collecting & validating the data

Collecting and verifying the data is a big job…
but necessary if one wants to be able to do quantitative global studies.

Establishing a useful data collection is considerably harder for ***quantitative*** *applications than* ***qualitative*** *ones.*

This group has a many-year-long successful history in reviewing experimental data, validating results, extracting information from collaborations

This is a collaborative effort between

- ***Durham/PDG…….Mike Whalley et al.***

and xsec-groups of neutrino experiment collaborations

- ***K2K……..Makoto Sakuda et al.***
- ***Mini-BooNE…….Sam Zeller et al.***
- ***MINOS……..……Hugh Gallagher et al.***

These collaborations (with experiments running well before us) have / will have xsec data needed for tuning our neutrino interaction model

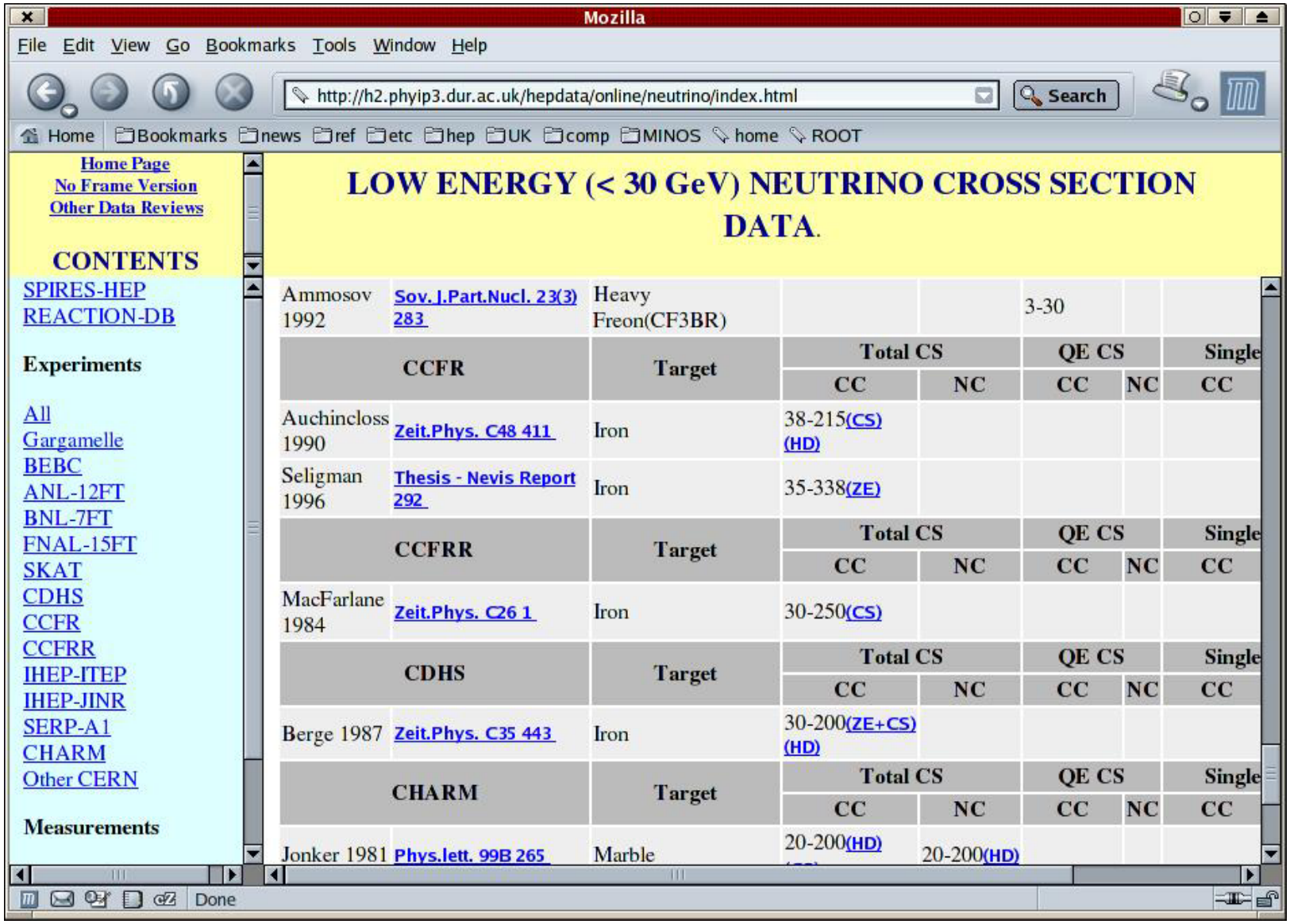
The formation of this "collaboration" of relevant parties

was initiated *(after the September MINOS meeting)* by MINOS

& we had few phone-conferences over the past 3 months

The DURHAM Neutrino Cross Section Web Site

Durham web site maintained by M. Whalley:



NuValidator: An Overview

- ***XML input***
*(custom **DTD** for describing xsecs, form factors, experimental info, citations, beam spectra…)*

- ***C++ XML parser based on GNOME's libxml2***

- ***C++/STL-based data structures for parsed data***

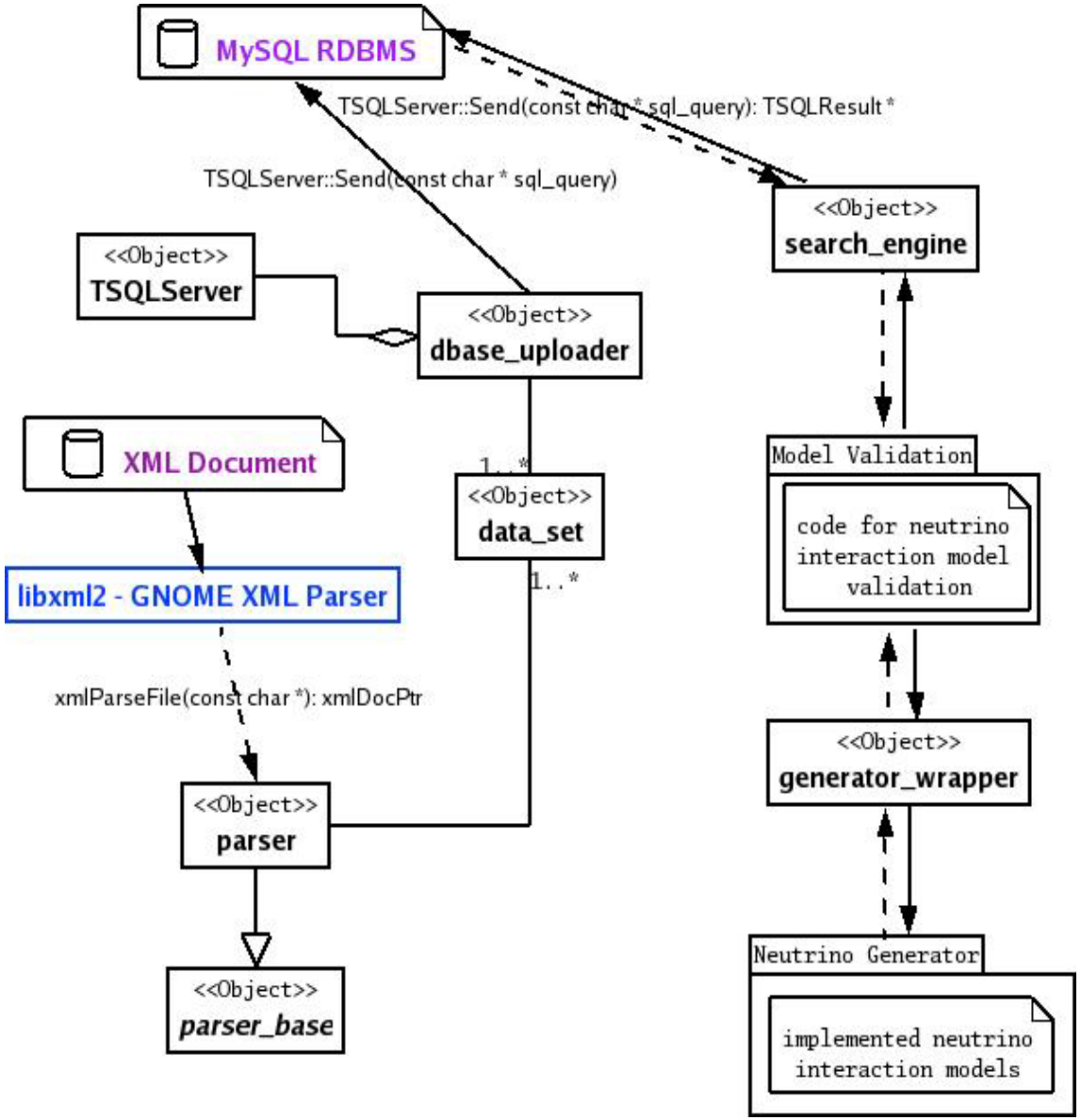
- ***MySQL RDBMS for keeping data***

- ***Predefined SQL queries***

- ***SQL Results presented in convenient formats*** *(eg. TGraphAsymmErrors,…)*

- ***Interfaces to Neutrino Generator(s)***

- ***Analysis modules*** *for quantitative analysis between data & neutrino generator predictions*



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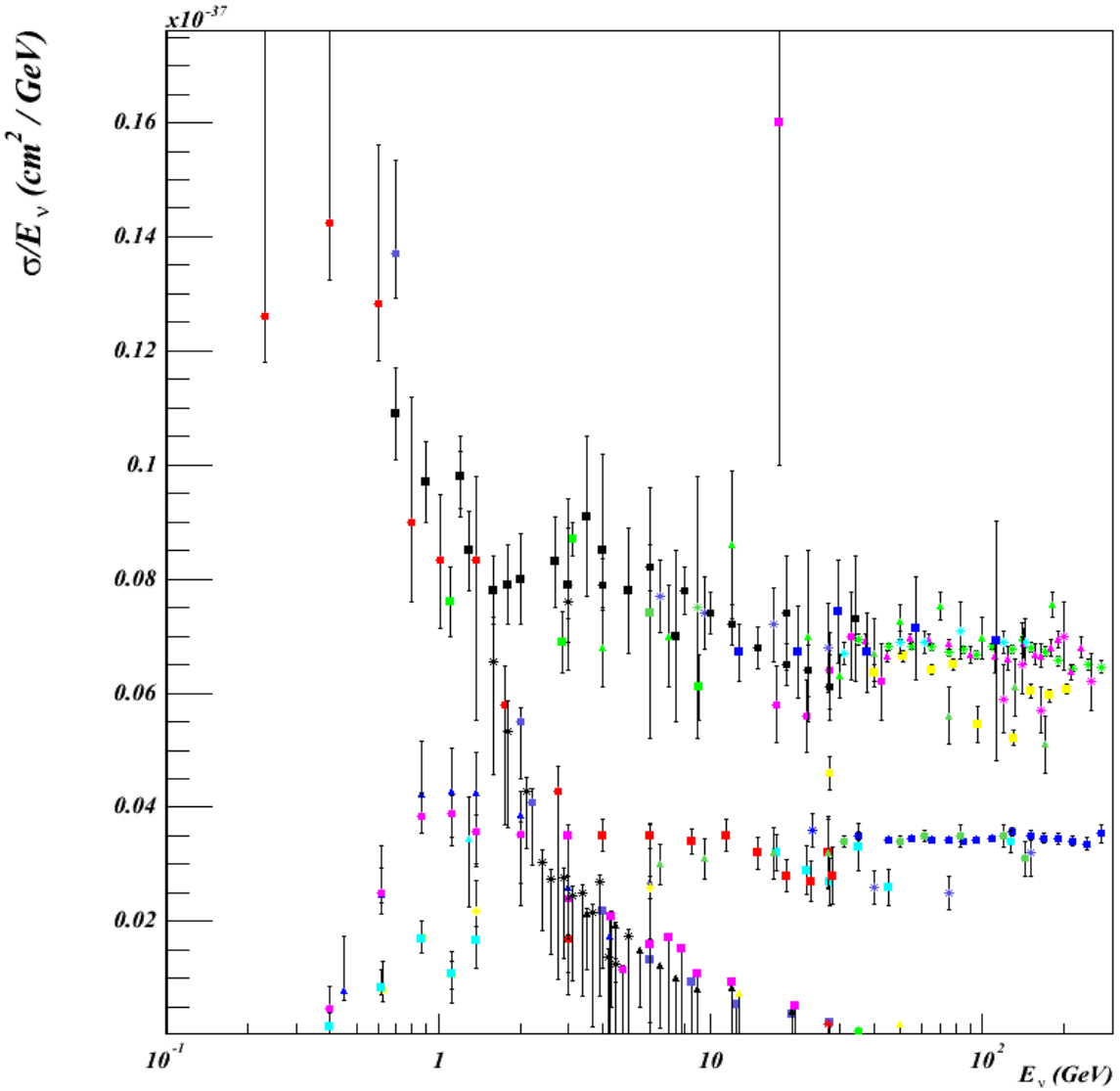
Latest dbase dump: XML-ized xsec data



- ANL_12FT: nu_mu N --> mu- X - Barish et al. Phys.Lett. 66B 2911976
- ANL_12FT: nu_mu n --> mu- p - Barish et al. Phys.Rev. D16 31031977
- ANL_12FT: nu_mu N --> mu- X - Barish et al. Phys.Rev. D19 25211979
- ANL_12FT: nu_mu p --> p pi+ mu- - Barish et al. Phys.Rev. D19 25211979
- ANL_12FT: nu_mu n --> p pi0 mu- - Barish et al. Phys.Rev. D19 25211979
- ANL_12FT: nu_mu p --> p pi+ mu- - Radecky et al. Phys.Rev. D25 11611982
- ANL_12FT: nu_mu n --> p pi0 mu- - Radecky et al. Phys.Rev. D25 11611982
- BEBC: nu_mu N --> mu- X - Bosseti et al. Phys. Lett. 70B 2731977
- BEBC: nu_mu_bar N --> mu+ X - Bosseti et al. Phys. Lett. 70B 2731977
- BEBC: nu_mu N --> mu- X - Colley et al. Zeit. Phys. C2 1871979
- BEBC: nu_mu_bar N --> mu+ X - Colley et al. Zeit. Phys. C2 1871979
- BEBC: nu_mu N --> mu- X - Bossetiet al. Phys.Lett. 110B 1671982
- BEBC: nu_mu_bar N --> mu+ X - Parker et al. Nucl. Phys. 232B 11984
- BEBC: nu_mu N --> mu- X - Parker et al. Nucl. Phys. 232B 11984
- BEBC: nu_mu A --> mu- A pi+ - Marage et al. Z.Phys. C43 5231989
- BNL_7FT: nu_mu_bar p --> mu+ X - Fanourakis et al. Phys.Rev. D21 5621980
- BNL_7FT: nu_mu N --> mu- X - Baltay et al. Phys.Rev.Lett.44 9161980
- BNL_7FT: nu_mu n --> mu- p - Baker et al. Phys.Rev.D23 24991981
- BNL_7FT: nu_mu N --> mu- X - Baker et al. Phys.Rev.D23 24991981
- CCFR: nu_mu N --> mu- X - Seligman Nevis Report 2921996
- CCFR: nu_mu_bar N --> mu+ X - Seligman Nevis Report 2921996
- CCFR: nu_mu N --> mu- X - Auchincloss et al. Zeit.Phys. C48 111990
- CCFRR: nu_mu N --> mu- X - MacFarlane et al. Zeit.Phys. C26 11984
- CDHS: nu_mu N --> mu- X - Berge et al. Zeit. Phys. C35 4431987
- CDHS: nu_mu_bar N --> mu+ X - Berge et al. Zeit. Phys. C35 4431987
- CHARM: nu_mu n --> mu- p - Belikov et al. Yad.Fiz.35 591982
- CHARM: nu_mu n --> mu- p - Belikov et al. Yad.Fiz.41 9191985
- FNAL_15FT: nu_mu p --> p pi+ mu- - Bell et al. Phys.Rev.Lett. 41 10081978
- FNAL_15FT: nu_mu_bar p --> p pi- mu+ - Barish et al. Phys.Lett.B91 1611980
- FNAL_15FT: nu_mu N --> mu- X - Kitagaki et al. Phys.Rev.Lett.49 981982
- FNAL_15FT: nu_mu n --> mu- p - Kitagaki et al. Phys.Rev.D28 4361983
- FNAL_15FT: nu_mu N --> mu- X - Baker et al. Phys.Rev.Lett.51 7351983
- FNAL_15FT: nu_mu_bar N --> mu+ X - Taylor et al. Phys.Rev.Lett.51 7391983
- Gargamelle: nu_mu N --> mu- X - Eichten et al. Phys.Lett. 46B 2741973
- Gargamelle: nu_mu N --> mu- X - Eichten et al. Phys.Lett. 46B 2741973
- Gargamelle: nu_mu n --> mu- p - S. Bonetti et al. Nuovo Cimento A38 2601977
- Gargamelle: nu_mu p --> p pi+ mu- - Lerche et al. Phys. Lett. 78B 5101978
- Gargamelle: nu_mu N --> mu- X - Ciampolillo et al. Phys. Lett. 84B 2811979
- Gargamelle: nu_mu_bar N --> mu+ X - Ciampolillo et al. Phys. Lett. 84B 2811979
- Gargamelle: nu_mu_bar N --> mu+ X - Erriquez et al. Phys. Lett. B80 3091979
- Gargamelle: nu_mu N --> mu- X - Morfin et al. Phys. Lett. 104B 2351981
- Gargamelle: nu_mu_bar N --> mu+ X - Morfin et al. Phys. Lett. 104B 2351981
- IHEP_ITEP: nu_mu_bar N --> mu+ X - Vovenko et al. Soviet J. Nucl. Phys. 30 5271980
- IHEP_ITEP: nu_mu N --> mu- X - Vovenko et al. Soviet J. Nucl. Phys. 30 5271980
- IHEP_JINR: nu_mu N --> mu- X - Anikeev et al. Zeit.Phys.C70 391996
- IHEP_JINR: nu_mu_bar N --> mu+ X - Anikeev et al. Zeit.Phys.C70 391996
- SKAT: nu_mu N --> mu- X - Baranov et al. Phys.Rev.B81 2551979
- SKAT: nu_mu A --> mu- A pi+ - Grabosch et al. Zeit.Phys.C31 2031986
- SKAT: nu_mu A --> nu_mu A pi0 - Grabosch et al. Zeit.Phys.C31 2031986
- SKAT: nu_mu n --> mu- p - Bruner et al. Zeit.Phys.C45 5511990

How do these XML data files look like?

```
<?xml version="1.0" encoding="ISO-8859-1" ?>

<nuscat_data version="0.01" update="2003-08-19">

 <experiment name="ABC77">
   <exp_info>
      <facility>                    Somewhere National Lab (SNL)  </facility>
      <detector>                    Bubble Chamber                </detector>
      <target>                      Freon                         </target>
      <exposure units="kgr*yr">     10                            </exposure>
      <year>                        1977                          </year>
      <beam>                        numu, nue                     </beam>
      <E frame="lab" units="GeV">   1 – 10                        </E>
     <nmeasurements>                1                             </nmeasurements>
   </exp_info>
   <measurement observable="qe_xsec">
      <header>
         <reaction>                 nu_mu n --> mu- p             </reaction>
         <auth>                     Someone et al.                </auth>
         <ref>                      Phys.Rev.Lett 56:1771 (1978)  </ref>
         <exposure units="pot">     2.4e+13                       </exposure>
         <npoints>                  2                             </npoints>
      </header>
      <point>
         <E units="GeV" frame="lab">     1.70,  +0.50,  -0.50  </E>
         <qe_xsec units="10^-38 cm^2">   1.03,  +0.22,  -0.18  </qe_xsec>
      </point>
      <point>
         <E units="GeV" frame="lab">     1.95, +0.50, -0.50</E>
         <qe_xsec units="10^-38 cm^2">   0.96, +0.16, -0.19</qe_xsec>
      </point>
   </measurement>
 </experiment>

</nuscat_data>
```

tree root element

experiment info

single measurement header

experimental points with errors

single measurement

single experiment *(potentially with many measurements)*

What XML stands for and why using it after all?

XML (eXtensible Markup Language)

- was designed to **describe data**
- **cross-platform compatibility**
- **self descriptive**
  - Uses a **DTD** (Document Type Definition) or an **XML Schema** to define the data

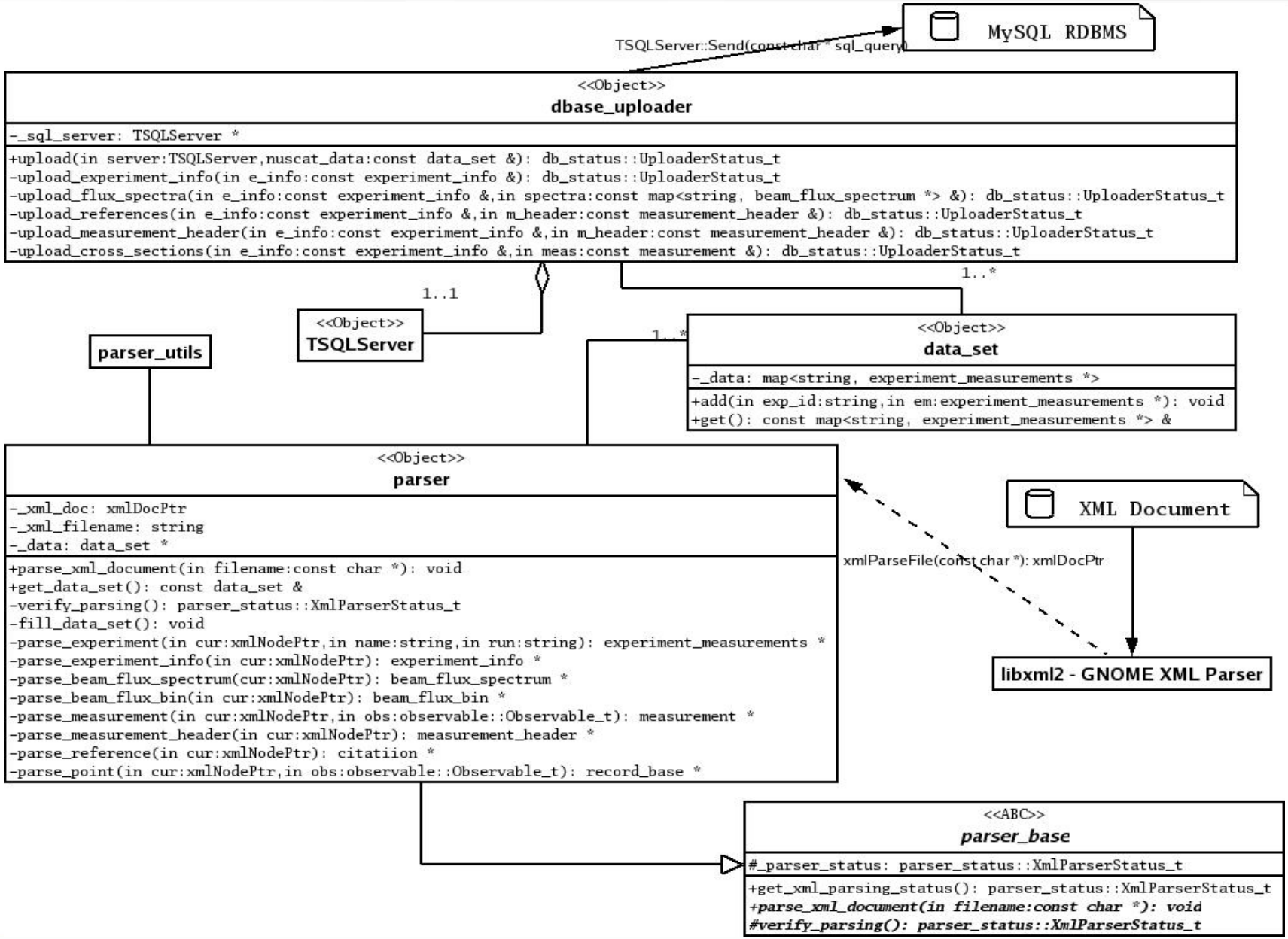
XML - W3C Recommendation: `http://www.w3.org/TR/xmlbase/`

For parsing the tree-structure of the XML document we use ***libxml2:***

The ***XML C Parser*** *and toolkit of* ***GNOME (*** *http://xmlsoft.org* ***)***

- *free software (MIT licence)*
- *portable (Linux, Unix, Windows, CygWin, MacOS, MacOS X, RISC Os, OS/2, VMS, QNX, MVS,…)*
- *written in C but wrappers / bindings available for other languages (C++, PERL…)*

XML parsing & RDBMS uploading



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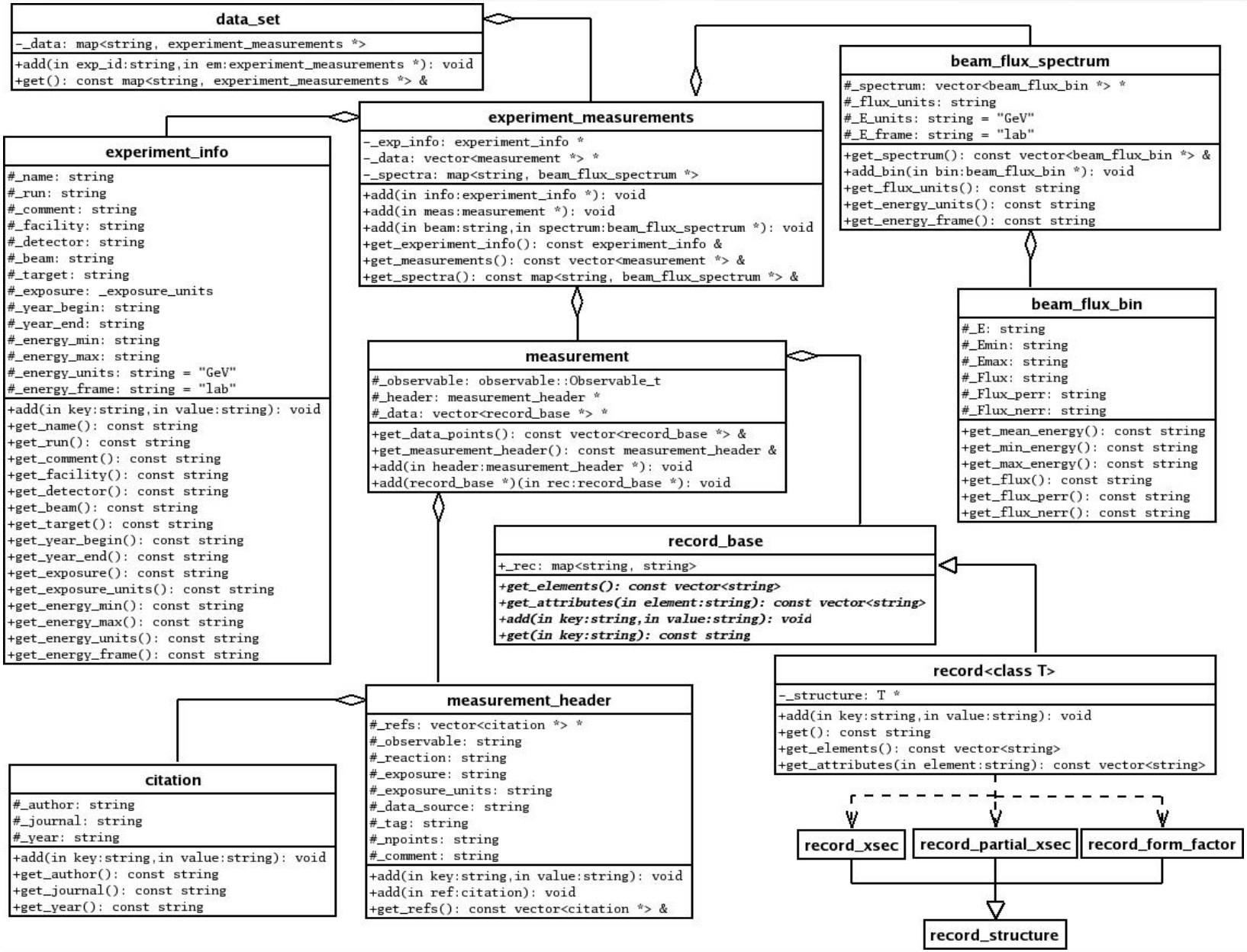
Parsed data "buffer"



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Current Status & Further work

- ***"Most" of the important functionality is in place***

- ***"Most" of the data that appear on the DURHAM web site are XML-ized and into our MySQL dbase***

- ***Future work:***

  - *Adding more data*
  - *Interface with neutrino generator(s) -- (NuGEN…)*
  - *Analysis modules for quantitatively evaluating the agreement of neutrino interaction models with the data, tuning model parameters etc…*

These will be soon implemented for an attempted, simple version of a "global fit" to xsec data

- *Extend the data base to hold measurements other than cross sections (form factors… etc)*
- *Adding a characteristic sample of electron scattering data*